AD-A133 476 DECISIONMAKING FOR ANTISUBMARINE WARFARE COMMANDERS(U) 1/1
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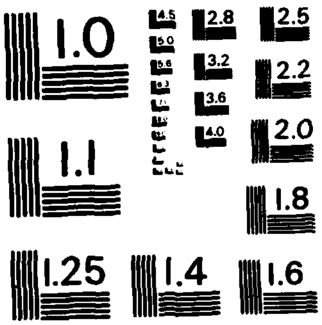

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ALPHATECH, INC.

AD-A133 476

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PROJECT STATUS REPORT

Contract Number N00014-81-C-0740

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Perspective

The primary goal of last year's effort was to model high-level decisionmaking for antisubmarine warfare commanders. To abet this modeling effort, the SHOR paradigm was presented as a structure for analyzing human cognitive decisionmaking. The commander's decisionmaking process was cast in the SHOR framework. A Bayesian mathematical model of the decisionmaker's hypothesis evaluation procedure was developed. The inputs to the model were the hypotheses and sensor data, and its outputs were the posterior probabilities of the hypotheses' being true and their respective states of nature. It was thought that these outputs would be sufficient for the commander to perform the option generation and evaluation activities.

Current Efforts

A further delineation of the decisionmaking process of the antisubmarine warfare commander and subsequent model is underway. The modeling effort, as depicted in Figure 1, is partitioned into three major modules: environmental driver, situation assessment, and resource management. Work on the environmental driver, ~~as discussed below~~, is almost complete. Descriptions of the latter two modules represent details of intended development.

Environmental Driver

The environmental driver produces estimates of one's own force state including all battle group platforms and sonobuoys, provides enemy submarine trajectories, and produces sonar contacts. A contact is comprised of sensor type, sensor location, bearing, range, and classification. Provisions have also been made to generate false contacts. It is assumed that probability of detection depends on sensor type, target range, and target class. The bearing, range, and classification error statistics are obtained from the Sharem Exercise reports. It should be noted that only passive sonar systems are modeled.

Situation Assessment

The situation assessment module is conceptualized as a cascading of three activities: (1) data clustering, (2) data association, and (3) state estimation as shown in Figure 2. The objective of the data clustering process is to synthesize the raw data occurring simultaneously into manageable groups and to take account of the inherent low reliability of the sonar contact data. Thus, each cluster will have associated with it a bearing, a probability density for range, and a probability mass function for identity.

Data association permits two metahypotheses about contacts; i.e., the contact is a start (tentative target) or it belongs to an established track (confirmed target). Track association is performed on the basis of the residuals produced in a comparison of the data with the prediction made supposing that the track in question is, in fact, the true track. Typically, a measurement is associated with a track if the absolute value of the residual is less than some arbitrary value (so-called gate condition). If the data cannot be associated with any of the available tracks, the procedure is reiterated for all starts. The maximum number of starts and tracks that can be considered at any decision time are fixed and constant.

At each time step, only those tracks with likelihoods of being real targets exceeding some threshold are maintained. The starts, then, with the highest likelihood of being real targets become tracks until the track stack is filled to capacity. Similarly, data not associated with any known start become new starts if empty slots exist in the starts queue. The output of the data association process are the associations between the data and the starts and tracks hypotheses.

The purpose of the target state estimation process is to update state estimates, error covariances, and likelihoods of all starts and tracks being in fact "true" targets in light of the data associations at each time step. Data is transformed into state estimates, predictions, and likelihoods using Kalman filtering techniques. The state predictions and the likelihoods for starts and tracks are the outputs that are passed back to the data association process, while only the current state estimates and likelihoods of the tracks are output to the decisionmaking block.

Resource Management

The objective function of this decisionmaking module is assumed to be the reduction of track estimate uncertainty, consideration of the battle group vulnerability, and the maintenance of sensing and detection capability. Thus, outputs of resource management are commands to position ships, position the attack submarine, and deploy aircraft and helicopters on localization maneuvers.

Commanders are assumed to strive to make decisions in an optimal (normative) manner but to be limited by cognitive constraints. This gives rise to a normative-descriptive modeling approach. That is, the purely normative approach to decisionmaking is refined to account for the bounded rationality and the preferential inconsistency phenomena witnessed in human decisionmaking. The cognitive limitations have conventionally been dealt with by constraining people's ability to

attend to and process sensory signals (short-term memory) and applying simplified (heuristic) models in order to cope with their problems. There is, however, litt little agreement on the issue of how people process probabilistic information.

It is proposed, therefore, that an optimal decisionmaking procedure be constructed first because:

1) When the appropriate human limitations and biases are included, a metric to calculate the "cost" of the antisubmarine warfare commander's nonoptimal decision behavior will be available, and,

2) Cognitive limitations can be used as "tuning" parameters to make decisions more humanlike, since there is no a priori consensus on the antisubmarine warfare commander's ability to aggregate and process probabilistic information.

Additional decisionmaking considerations are subjective utility, which includes rate of change of uncertainty and the cost of deploying a resource, risk conceptualized as consequences of future contingencies and consequences of resource unavailability, the time available and time required to invoke an action, and the role of doctrine.

Although the terminology is different, the approach described is analogous to the SHOR paradigm. The environmental driver generates the stimuli from the environment, the situation assessment module forms hypotheses about the environment, and the resource management module evaluates available actions (options) to extremize some objective function.

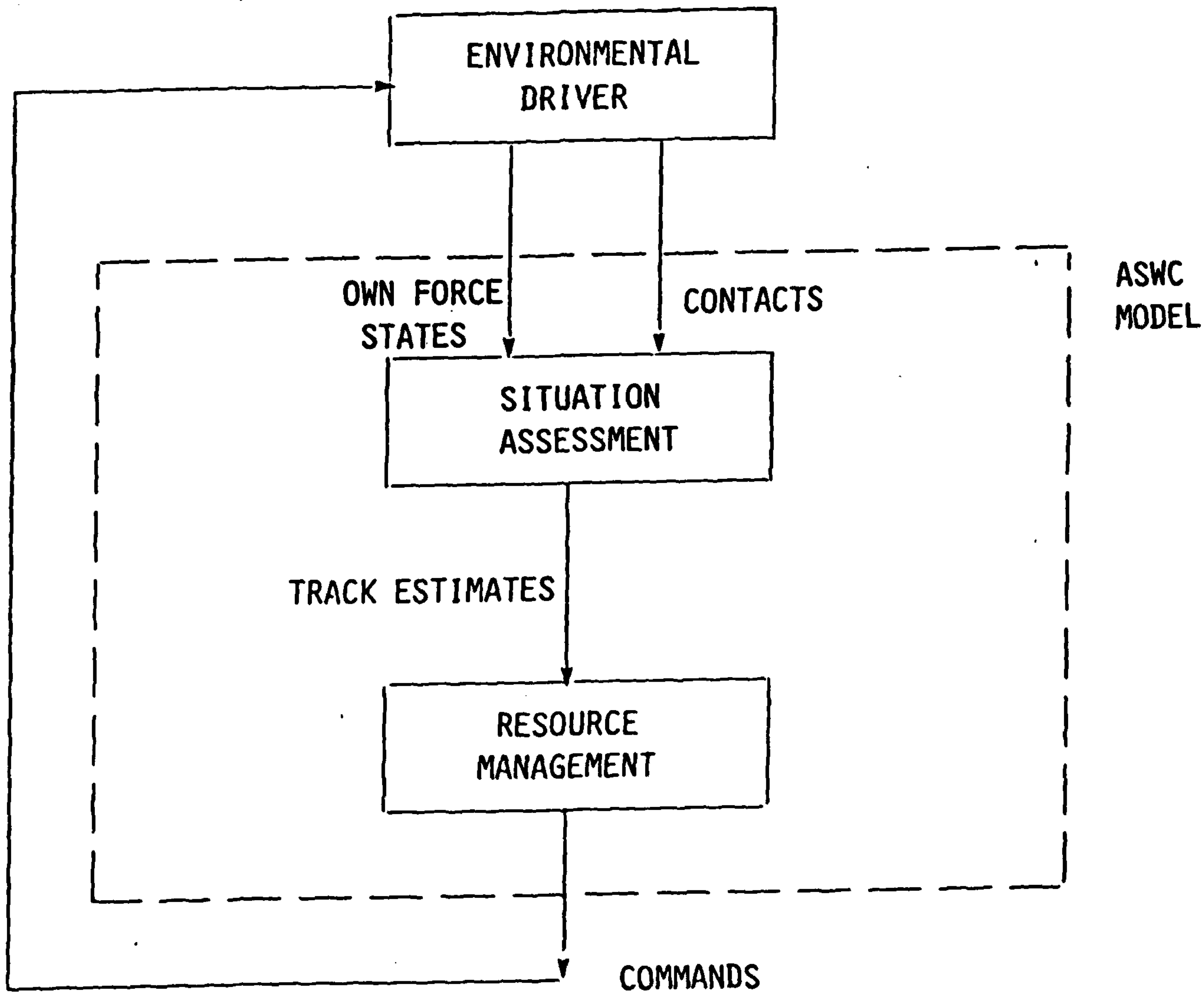

Figure 1. ASWC Model and Environmental Driver

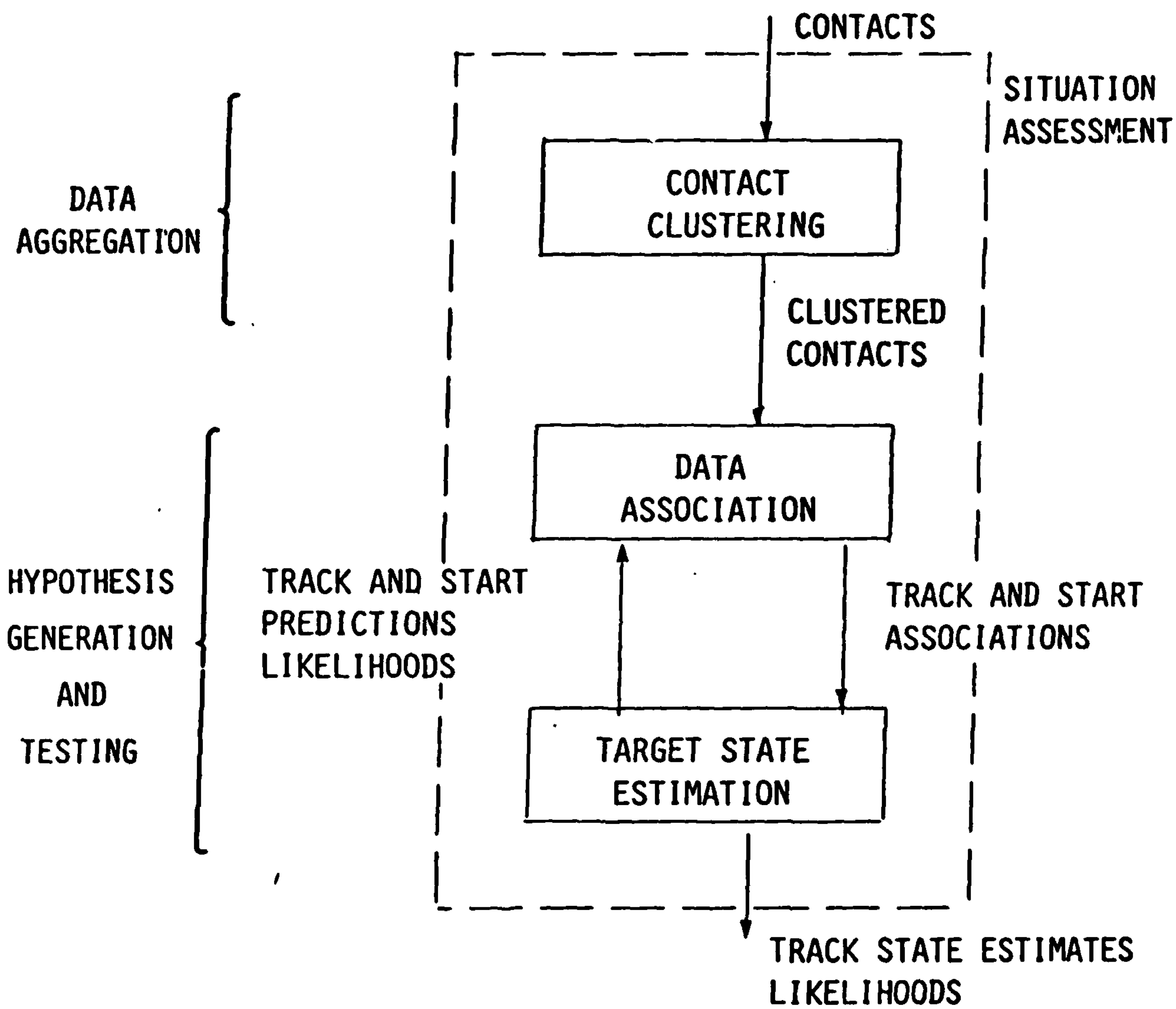

Figure 2. ASWC Situation Assessment Cognitive Model